The Muon-Induced Neutron Indirect Detection EXperiment MINIDEX

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Motivation

Underground experiments searching for rare events, like dark matter candidate WIMPs or neutrinoless double-beta decay, commonly use high-Z materials (such as copper and lead) as shielding. Cosmic muon induced neutrons from these materials could induce background events which are difficult to reject.

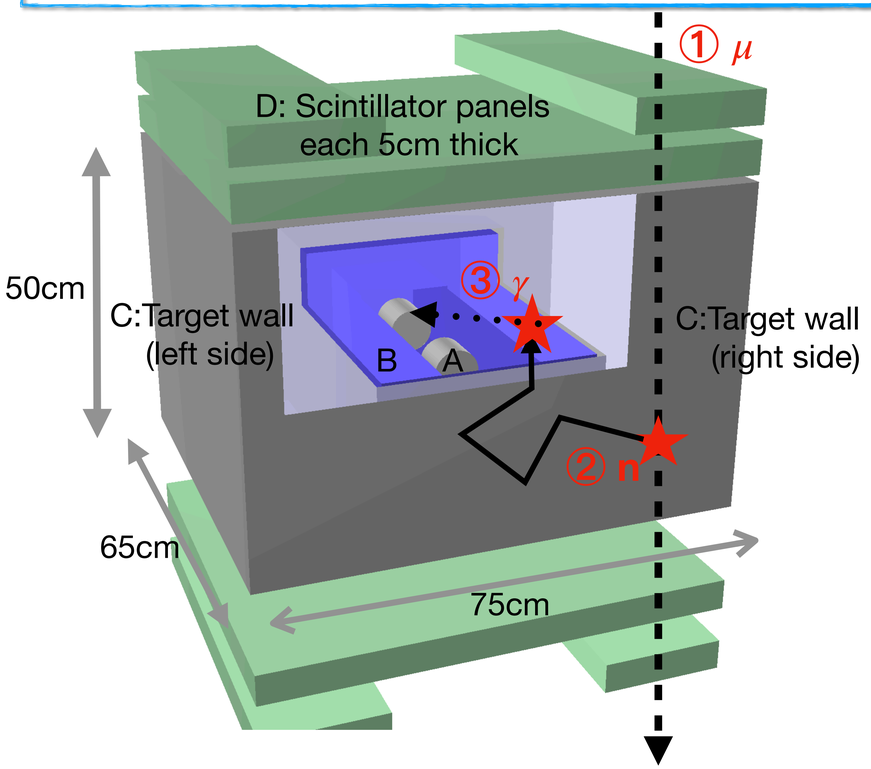
With MINIDEX, neutron fluxes from various materials are measured and compared with FLUKA and Geant4 Monte Carlo simulations in order to verify the simulation and improve its application in designing and optimising future experiments.

Experimental Design

MINIDEX is located in the shallow underground lab at the University of Tübingen, which has an overburden ~13 m.w.e..

Two High-Purity Germanium (HPGe) detectors (A) are surrounded by a water tank (B) which is encased in a castle (C) made from bricks of the chosen target material. MINIDEX defines two target walls from which the material can be chosen independently. Scintillator panels (D) are positioned above and below the target material to tag muons.

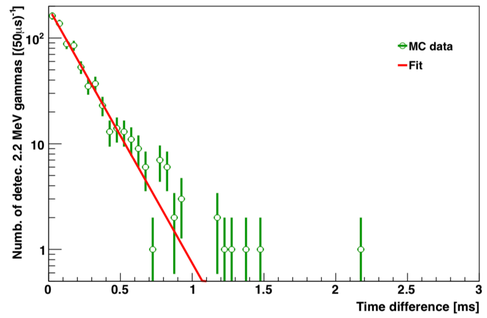
The neutron flux is determined using the 2.2MeV gammas from the neutron capture on hydrogen in the water tank as measured by the HPGe detectors.



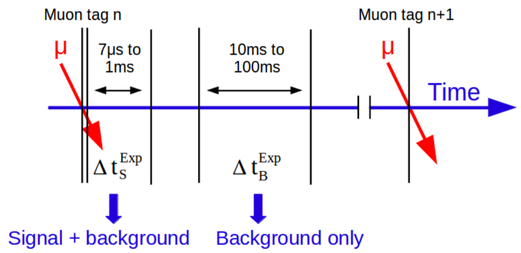
Measurement

① **Cosmic muons** through target walls are tagged by the scintillator panels.

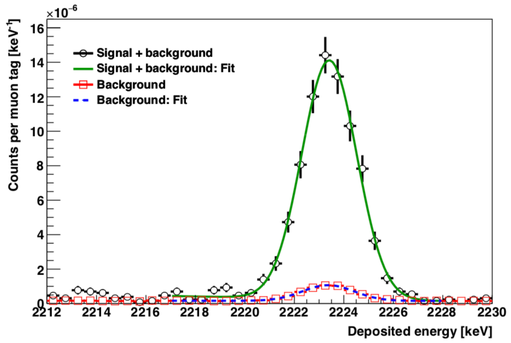
② **Muon-induced neutrons** in the target walls are thermalised and captured in the water tank with a half life time of ~160μs.



Based on the 160μs half life time, two time windows after the muon tag are defined.



③ **2.2 MeV gammas** from both time windows are measured in the HPGe detectors.



The number of 2.2MeV gamma per muon tag after subtracting the background is compared with the simulation.

Number of 2.2MeV gammas per through-going muon tag

	R_S $[10^{-5}]$
Lead	
Experiment	$3.52 \pm 0.11\,(\text{stat})\,^{+0.19}_{-0.14}\,(\text{syst})$
Geant4	$3.37 \pm 0.09\,(\text{stat}) \pm 0.09\,(\text{syst})$
Copper	
Experiment	$1.27 \pm 0.14\,(\text{stat}) \pm 0.06\,(\text{syst})$
Geant4	$1.77 \pm 0.10\,(\text{stat}) \pm 0.10\,(\text{syst})$

Measurement and simulation agree in general.

Detailed comparison suggests that Geant4 underestimates photo-nuclear interaction induced neutrons while overestimates muon-nuclear interaction induced neutrons.

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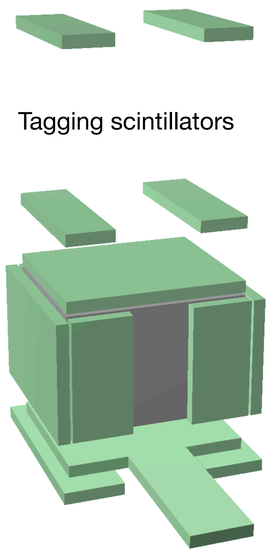
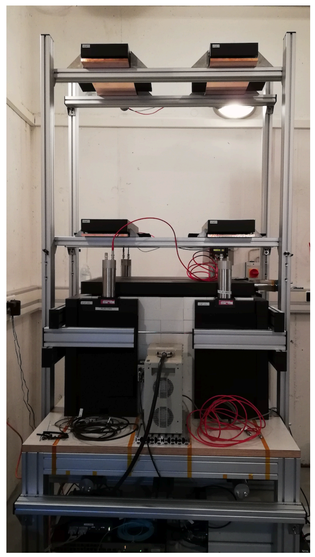
Ongoing upgrade:

Extra scintillator panels are added to veto through-going muons and to **measure muon-capture induced neutron flux.**





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